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E. P. Gross - Principal Investigator

Research carried out on this contract has been in the areas 1) Quantum theory of the many body problem with particular application to liquid helium; 2) The interaction of nonrelativistic particles and quantum fields; 3) Classical kinetic theory of gases. While each topic has its own distinctive feature, it also casts light on the other topics.

We have been particularly concerned with liquid helium because it is one of the simplest many body systems and yet has an incredible richness of behavior. It may in time become the best understood many body system and serve as a prototype for other studies. The pattern of investigation is 1) An understanding of the qualitatively distinct possible ground states for a system of interacting bosons (gas, liquid, solid, etc.); 2) Characterization of the possible excitations, i.e., phonon-roton spectrum, shear waves, vortices; 3) Analysis of the effects of probes, i.e., x-rays, inelastic scattering of neutrons, foreign atom and ion behavior, etc.; 4) Statistical thermodynamics; 5) Kinetics of interactions of excitations and the microscopic derivation of two fluid hydrodynamics.

Our work has been mainly on the first three topics, and is contained in the following papers:

Hydrodynamics of a Superfluid Condensate - J. Math. Phys. (in press).

Motion of Foreign Bodies in Boson Systems - Annals of Physics 19, 234 (1962).

Structure of a Quantized Vortex - Il Nuovo Cimento 20, 454 (1961).

Quantum Theory of Interacting Bosons - Annals of Physics 2, 292 (1960).

Classical Theory of Boson Wave Fields - Annals of Physics 4, 57 (1958).

The first paper in particular gives a summary of the present status of these questions and complements the proposal submitted to continue the work on a grant status.

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RESEARCH

AFOSR 49(638)-27

Our work on the interaction of a nonrelativistic particle with a quantized field has been reported in

Particle-Like Solutions in Field Theory - Annals of Physics 19, 219 (1962).

Analytic Methods in the Theory of Electron Lattice Interactions - Annals of Physics 8, 78 (1959).

Small Oscillation Theory of Interaction - Phys. Rev. 100, 1571 (1955).

This research is closely related to the boson theory in its emphasis on analysis of the qualitatively distinct possible ground states and on the use of small oscillation techniques.

Our studies of the kinetic theory of gases has emphasized 1) the use of half range polynomial techniques to solve boundary value problems; 2) the use of kinetic models to replace and to approximate to the Boltzmann equation. We feel that our most significant paper in the past few years is

Kinetic Models and the Linearized Boltzmann Equation (with E. A. Jackson),  
Physics of Fluids 2, 432 (1959).

The use of kinetic models has now been widely adopted and we feel that our efforts would be best spent in extending the analysis of basic questions concerning the validity and scope of models.

This grant has contributed in recent years to the Ph.D. degree work of  
J. Vail - degree awarded 1969  
M. Eger - degree due in Feb. 1963.

*Raymond D. D. 10022*

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Supported by AFOSR 49(638)27

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